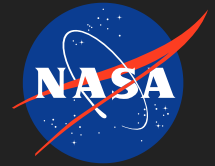


Testosterone Supplementation as a Countermeasure against Musculoskeletal Losses during Space Exploration

Completed Technology Project (2010 - 2016)



Project Introduction

The long-term goal of this proposal was to determine the therapeutic efficacy of testosterone at preserving lean muscle mass, muscle strength, and bone mineral density in healthy humans during spaceflight. We proposed to examine the interactive or additive effects of the combination of testosterone and exercise on lean body mass (LBM), muscle strength, and bone health. Our general hypothesis is that the maintenance of normal physiologic levels of testosterone during spaceflight will protect against the functional loss of muscle and bone, and will maximize the efficacy of existing resistance exercise protocols at preventing or reversing functional impairments that occur during bed rest.

To achieve these goals we tested the following specific hypotheses before, during, and after 70 days of bed rest:

1: Cycled testosterone replacement (weekly testosterone injections for 2 weeks, followed by 2 weeks off, etc.) in conjunction with exercise will have an additive effect in preventing loss of muscle mass and muscle strength in men representative of the astronaut population compared to exercise with placebo testosterone.

2: Cycled testosterone replacement (weekly testosterone injections for 2 weeks, followed by 2 weeks off, etc.) in conjunction with exercise will have an additive effect in preventing loss of bone mass and alterations in markers of bone metabolism in men representative of the astronaut population compared to exercise with placebo testosterone.

To address these hypotheses we investigated the following specific aims before, during, and after 70 days of bed rest:

Aim 1: To determine the effect of cycled testosterone replacement in conjunction with resistance exercise during bed rest on muscle mass, muscle strength, and fatigue in men aged 24-55 years.

Aim 2: To determine the effect of cycled testosterone replacement in conjunction with resistance exercise during bed rest on markers of bone metabolism and bone mass in men aged 24-55 years.

Anticipated Benefits

Results from this study will further elucidate the role of testosterone in the maintenance of skeletal muscle and bone during long term bed rest and spaceflight. The benefits to life on Earth are extensive.

This study demonstrates that testosterone treatment in conjunction with exercise countermeasures is corrective against head down bed rest (HDBR) induced changes in body composition of healthy men. Exercise countermeasures were protective against HDBR induced declines in LBM and



Testosterone Supplementation as a Countermeasure against Musculoskeletal Losses during Space Exploration

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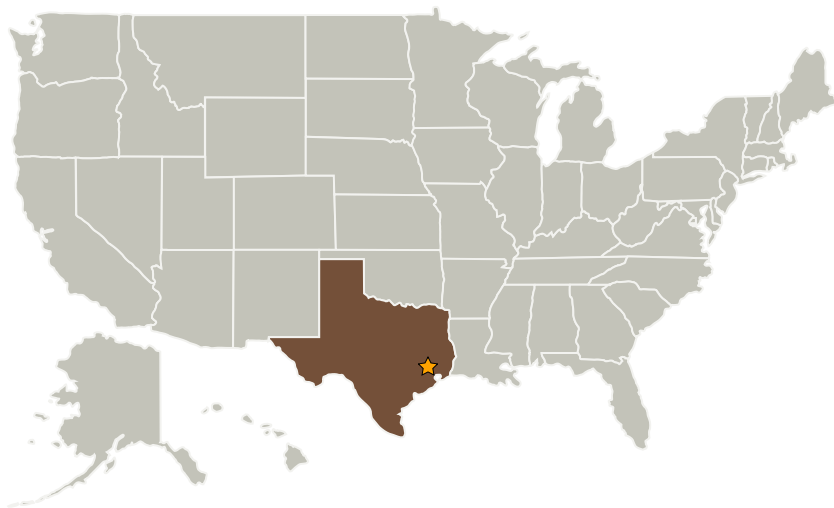
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strength. However, the addition of low dose intermittent testosterone treatment was necessary to promote increases in LBM and protect against increases in fat mass. Furthermore, changes in leg LBM correlated directly with changes in lower body strength. Understanding the unique synergy between exercise dosing and testosterone supplementation could have important implications for both clinical outcomes and spaceflight operations.

Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
★ Johnson Space Center(JSC)	Lead Organization	NASA Center	Houston, Texas
The University of Texas Medical Branch at Galveston(UTMD-Galv.)	Supporting Organization	Academia	Galveston, Texas

Primary U.S. Work Locations

Texas

Organizational Responsibility

Responsible Mission Directorate:

Space Operations Mission Directorate (SOMD)

Lead Center / Facility:

Johnson Space Center (JSC)

Responsible Program:

Human Spaceflight Capabilities

Project Management

Program Director:

David K Baumann

Project Manager:

Linda H Loerch

Principal Investigator:

Randall Urban

Co-Investigators:

Melinda Sheffield-moore
William Durham
Edgar L Dillon

Testosterone Supplementation as a Countermeasure against Musculoskeletal Losses during Space Exploration

Completed Technology Project (2010 - 2016)



Project Transitions

July 2010: Project Start

July 2016: Closed out

Closeout Summary: This study has been completed and all main outcome measures have been analyzed. Manuscripts are in development and will be submitted for peer-review and publication. The following main outcomes occurred with the addition of testosterone countermeasure to exercise: - Did not negatively alter hormonal or lipid profiles. - Increased lean body mass compared to Control and Exercise plus placebo. - Prevented an increase in fat mass that occurred in Control and Exercise plus placebo. - Prevented loss in calf strength compared to Control and Exercise plus placebo. Additionally, Exercise with or without Testosterone: - Blunted declines in strength compared to Control. - Prevented late onset declines in pelvic bone density observed in Control but had no discernible effects on bone mass in other regions.

Stories

Abstracts for Journals and Proceedings
(<https://techport.nasa.gov/file/60337>)

Abstracts for Journals and Proceedings
(<https://techport.nasa.gov/file/60341>)

Abstracts for Journals and Proceedings
(<https://techport.nasa.gov/file/60342>)

Abstracts for Journals and Proceedings
(<https://techport.nasa.gov/file/60343>)

Abstracts for Journals and Proceedings
(<https://techport.nasa.gov/file/60344>)

Articles in Peer-reviewed Journals
(<https://techport.nasa.gov/file/60339>)

Articles in Peer-reviewed Journals
(<https://techport.nasa.gov/file/60345>)

Articles in Peer-reviewed Journals
(<https://techport.nasa.gov/file/60340>)

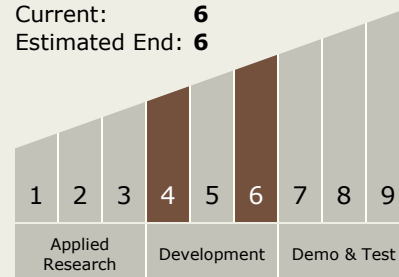
Articles in Peer-reviewed Journals
(<https://techport.nasa.gov/file/60338>)

Project Website:

<https://taskbook.nasaprs.com>

Technology Maturity (TRL)

Start: **4**
Current: **6**
Estimated End: **6**



Technology Areas

Primary:

- TX06 Human Health, Life Support, and Habitation Systems
 - └ TX06.3 Human Health and Performance
 - └ TX06.3.2 Prevention and Countermeasures

Target Destinations

The Moon, Mars